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REVIEW ARTICLE

Psoas compartment block for lower extremity surgery: a meta-analysis

S. T. Touray[1], M. A. de Leeuw[2]*, W. W. A. Zuurmond[1] and R. S. G. M. Perez[1 3]

[1]Department of Anaesthesia and Pain Medicine, VU University Medical Centre, PO Box 7057, 1007 MB Amsterdam, The Netherlands. [2]Department of Anaesthesia and Intensive Care, Zaans Medical Centre, PO Box 210, 1500 EE Zaandam, The Netherlands. [3]Institute for Research in Extramural Medicine (EMGO), PO Box 7057, 1007 MB Amsterdam, The Netherlands

**Corresponding author. E-mail: ma.deleeuw@planet.nl*

Psoas compartment block (PCB) is a potentially useful but controversial technique for lower limb surgery. We have conducted a systematic review of the efficacy and safety of PCB for anaesthesia and postoperative analgesia for hip and knee surgery. Relevant studies were identified within PubMed, EMBASE, and the Cochrane Library. The main outcome measure for anaesthesia was anaesthetic efficacy. For postoperative analgesia, the severity of postoperative pain was compared. The data were subjected to meta-analysis using relative risks with 95% confidence intervals (95% CI) for dichotomous variables and weighted mean differences with 95% CI for continuous variables. Thirty publications were included. PCB is an effective intervention for analgesia after hip and knee surgery. It appears superior to opioids for pain relief after hip surgery. This analgesic benefit may be extended beyond 8 h by the use of a catheter technique. Compared with Winnie's 3-in-1 block, PCB is associated with more consistent block of the obturator nerve. PCB may be an alternative to postoperative neuraxial block. Although PCB combined with sciatic nerve block and sedation is an effective technique for minor knee surgery, there is currently insufficient data to recommend the use of this approach for hip and major knee surgery. PCB is a safe and effective alternative for analgesia after hip and knee surgery. More research is required to define its role in the intraoperative setting and confirm potentially beneficial effects on variables such as perioperative haemodynamics and blood loss.

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Lower limb orthopaedic interventions such as total hip arthroplasty (THA) and total knee arthroplasty (TKA) present a challenge to the anaesthetist, as these procedures typically involve elderly patients often suffering from multiple co-morbid conditions. In addition, these procedures generate significant postoperative pain.[31] Anaesthetic management usually involves the use of central neuraxial blocks or general anaesthesia (GA), with systemic analgesics administered for pain after surgery. The psoas compartment block (PCB) is an alternative approach which may circumvent many of the side-effects associated with these techniques. Combined with a sciatic nerve block, unilateral anaesthesia of the lower limb may be induced ('Psoas compartment sciatic nerve block or PCSNB'). Today PCB remains underutilized due to the familiarity and proven track record of alternative techniques such as neuraxial block and GA. Case reports describing life-threatening complications such as seizures and cardiac arrest as a result of local anaesthetic toxicity have resulted in some resistance to the routine use of PCB.[3]

This systematic review was conducted to evaluate the efficacy and safety of PCB compared with conventional anaesthetic techniques for hip and knee surgery in both the intraoperative and the postoperative settings. For intraoperative anaesthesia, PCB is compared with GA and neuraxial anaesthesia. For postoperative analgesia, PCB is compared with opioids, neuraxial block, and '3-in-1' or femoral nerve block (FNB). We proposed that the performance of PCB is at least equivalent to the alternative anaesthetic techniques investigated.

An electronic search of PubMed, EMBASE, and the Cochrane Library up to December 2007 was carried out using the following search terms: 'nerve block', 'psoas compartment', 'lumbar paravertebral', 'lumbar plexus', 'sciatic',

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and 'parasacral'. Reference lists of identified studies were scanned for additional relevant undetected publications. The following inclusion criteria were applied.

(i) *Types of studies*: randomized-controlled trials (RCTs), case-controlled studies, and case series.
(ii) *Types of participants*: only studies involving adult patients.
(iii) *Types of interventions*:
   (a) for intraoperative anaesthesia, studies in which PCB was compared with either GA or neuraxial anaesthesia;
   (b) for postoperative analgesia, studies in which PCB was compared with opiates, '3-in-1' or FNB, or neuraxial block;
   (c) in terms of surgery, only studies involving hip or knee surgery.
(iv) *Types of outcomes*:
   (a) for intraoperative anaesthesia, anaesthetic success rates were compared. 'Anaesthetic success' was defined as the ability to successfully complete surgery using either PCB alone or PCB combined with a sciatic nerve block, or PCB combined with a sciatic nerve block and sedation;
   (b) for analgesia after surgery, studies using measures of pain quantified using a visual analogue scale (VAS, zero, no pain; 10, worst pain imagined) or postoperative analgesic consumption;
   (c) studies assessing the degree of the sensory block, the motor block, or both generated by PCB;
   (d) the pharmacokinetic studies reporting plasma levels of local anaesthetic after injection into the psoas compartment.

Data pertaining to the type of surgery, population characteristics, interventions, outcomes, and results were extracted from the studies and tabulated. Methodological quality of the studies was assessed using the Jadad criteria[19] (Table 1). Within each of the investigated comparisons, outcome data were grouped and analysed both qualitatively and quantitatively. Qualitative analysis involved a synthesis of best evidence using a system of levels of evidence and grades of recommendation[39] (Table 1). High-quality studies were distinguished from low-quality studies using the methodological quality

Table 1 Methodological quality (1, yes; 0, no; and ?, unknown). *Case series; **case-controlled study. Levels of evidence:[39] *Level A1*: systematic review including two or more trials of level A2 and generally consistent results across the trials. *Level A2*: high-quality double-blind RCT of adequate power and consistency. *Level B*: randomized trials of low quality, inadequate power, or both or case-controlled studies. *Level C*: non-analytic studies, e.g. case reports and case series. Grades of recommendations:[39] *Grade 1*: systematic review or at least two independent studies of level A2. *Grade 2*: two or more level B studies. *Grade 3*: one study of level A2 or B or level C studies

	Jadad criteria						
	Randomized?	**Appropriately randomized?**	**Double-blind?**	**Appropriate blinding?**	**Withdrawals and dropouts?**	**Total score**	**Level of evidence**
Aldahish and colleagues[1]	1	?	?	?	1	2	B
Becchi and colleagues[4]	1	?	0	0	0	1	B
Biboulet and colleagues[5]	1	?	1	?	1	3	A2
Bogoch and colleagues[6]	1	1	1	1	1	5	A2
Buckenmaier and colleagues[7]*	—	—	—	—	—	—	C
Chelly and colleagues[8]**	—	—	—	—	—	—	B
Chudinov and colleagues[9]	1	?	0	—	0	1	B
Farny and colleagues[11]*	—	—	—	—	—	—	C
Gaillat and colleagues[12]*	—	—	—	—	—	—	C
Ganidagli and colleagues[13]	1	?	0	—	0	1	B
Hadzic and colleagues[14]	1	1	0	—	1	3	A2
Jankowski and colleagues[20]	1	?	?	?	1	2	B
Kaloul and colleagues[21]	1	1	?	?	?	2	B
Kaloul and colleagues[22]	1	1	?	?	1	3	A2
Luber and colleagues[24]*	—	—	—	—	—	—	C
Morin and colleagues[27]	1	1	?	?	1	3	A2
Odoom and colleagues[28]	1	?	?	?	1	2	B
Ozalp and colleagues[29]	1	?	?	?	1	2	B
Parkinson and colleagues[30]	1	?	?	?	?	1	B
Raimer and colleagues[32]	1	?	?	?	1	2	B
Siddiqui and colleagues[33]	1	1	0	0	1	3	A2
Simon and colleagues[34]*	—	—	—	—	—	—	C
Souron and colleagues[35]	1	1	?	?	—	2	B
Stevens and colleagues[36]	1	?	1	?	—	2	B
Tokat and colleagues[37]	1	?	?	?	0	1	B
Turker and colleagues[38]	1	?	0	0	—	1	B
Vanterpool and colleagues[40]	1	0	0	0	0	1	B
de Visme and colleagues[10]	1	?	0	—	—	1	B
Vree and colleagues[41]*	—	—	—	—	—	—	C
Watson and colleagues[42]	1	1	1	?	1	4	A2

scores of the individual studies as measured using the Jadad criteria. Studies fulfilling three or more of the Jadad criteria were arbitrarily defined as high quality.

Quantitative analysis or meta-analysis was conducted, if the studies were clinically and statistically homogenous. Statistical homogeneity was assessed using the χ^2 test with $P<0.05$ considered significant. If the studies were found to be homogenous, the outcome data were pooled using a fixed-effects model. In the case of significant statistical heterogeneity, reasons for heterogeneity were explored and the data were pooled using a random-effects model. To enable meta-analysis, data had to be presented in the form of mean and standard deviation. If data were summarized using the median with a corresponding range, the mean and standard deviation of the data were estimated using the formulae derived by Hozo and colleagues.[18] All meta-analyses were conducted using the software program RevMan® version 4.2 (Cochrane Collaboration, Oxford, UK) with effect sizes expressed as relative risk (RR) ratios with 95% confidence intervals (95% CI) for dichotomous variables and weighted mean differences (WMD) with 95% CI for continuous variables. Data were depicted in the form of forest plots. A WMD <0 indicates a superior effect of PCB. Statistical significance is indicated by a 95% CI interval not including zero. For RR, a ratio >1 indicates a superior effect of PCB with statistical significance inferred by a 95% CI not including '1'.

Results

The literature search resulted in inclusion of 20 RCT,[1 4–6 9 10 13 14 20 21 27 29 30 32 33 35–38 42] one case-controlled study,[8] three case series,[7 12 24] and six pharmacokinetic studies.[11 22 28 34 40 41] Methodological quality and levels of evidence of the various studies are listed in Table 1. Study characteristics are given in Table 2.

PCB for anaesthesia for hip surgery

Two case series were identified, in which a total of 21 patients for THA were successfully operated on using PCSNB combined with propofol sedation.[7 12] One RCT compared PCSNB with spinal anaesthesia for hip surgery.[10] Spinal anaesthesia resulted in the sensory block to a mean level of the eighth thoracic dermatome with no block failures. In the PCSNB group, anaesthesia was judged inadequate in four of the 15 patients (27%). Three of the four patients reported pain at incision that was relieved by a single bolus of alfentanil 250 μg, whereas the fourth patient required sedation.

Conclusion

There is insufficient evidence to support the use of PCB combined with a sciatic nerve block and sedation as an alternative to GA or spinal anaesthesia for hip surgery [Grade 3: Buckenmaier and colleagues[7] (C), Gaillat and colleagues[12] (C), and de Visme and colleagues[10] (B)].

PCB for analgesia after hip surgery

Two RCTs compared PCB with neuraxial block for analgesia after THA. Turker and colleagues[38] compared PCB with epidural analgesia and found no statistically significant difference in VAS pain scores and consumption of rescue analgesia after surgery. Souron and colleagues[35] compared single-injection PCB with 0.1 mg of intrathecal morphine for THA. The spinal morphine group had lower VAS pain scores and also required less rescue morphine during the first 48 h after surgery ($P<0.05$).

One study compared PCB with FNB.[5] VAS pain scores at rest were lower in the PCB group immediately after extubation and during the first 4 h after surgery ($P=0.001$). During mobilization, no difference in VAS pain scores was noted. Hourly morphine consumption was also lower in the PCB group during the first 4 h after operation ($P<0.002$).

Three studies compared single-injection PCB with i.v. opioids for pain after THA.[5 6 36] The data from two of these studies were pooled using a fixed-effects model. This resulted in a WMD in VAS pain scores of −1.20 (−1.82, −0.58) at 0–4 h and −1.07 (−1.72, −0.41) at 4–8 h, both in favour of PCB. After 8 h, there was no significant difference in pain scores (Fig. 1). Pooling of the data on postoperative opioid consumption from these two studies resulted in a WMD of −7.83 (−10.14, −5.52) at 4–8 h, −6.77 (−10.06, −3.48) at 8–12 h, and −6.10 (−10.98, −1.22) at 20–24 h, all in favour of PCB (Fig. 2). The study by Bogoch and colleagues[6] was excluded from meta-analysis as it included a mix of THA and TKA patients.

Four studies compared continuous PCB with opiates.[4 8 9 33] Chelly and colleagues[8] in a case-controlled study found that continuous PCB reduced 48 h morphine consumption by 60% ($P=0.001$ and 0.021 for days 1 and 2, respectively). Pooled analysis of the remaining three RCTs[4 9 33] resulted in a WMD of −2.71 (−3.25, −2.17) at 4–8 h, −2.87 (−3.45, −2.29) at 8–12 h, and −1.05 (−1.38, −0.72) at 20–24 h, all in favour of PCB (Fig. 3).

Conclusions

Compared with opioids for analgesia after hip surgery, it is likely that single-injection PCB reduces pain during the first 4–8 h after surgery [Grade 2: Biboulet and colleagues[5] (A2) and Stevens and colleagues[36] (B)]. This analgesic benefit may be extended beyond 8 h by the use of a continuous infusion [Grade 2: Becchi and colleagues[4] (B), Chudinov and colleagues[9] (B), Chelly and colleagues[8] (B), and Siddiqui and colleagues[33] (A2)].

Compared with other locoregional techniques for analgesia after hip surgery, there are indications that continuous PCB is equivalent to continuous epidural block [Grade 3: Turker and colleagues[38] (B)]. In addition,

Table 2 Included studies (NS, not significant)

Reference	Interventions	Outcomes
Aldahish and colleagues,[1] n=64, major knee surgery	Continuous PCSNB (n=32) *vs* lumbar epidural (n=32)	Anaesthetic success rate—NS; VAS pain scores—NS
Becchi and colleagues,[4] n=73, THA	PCB (n=37) *vs* morphine/ketorolac infusion (n=36)	VAS pain scores—lower in the plexus group ($P<0.0001$); rescue analgesia—lower in the plexus group during the first 24 h after surgery
Biboulet and colleagues,[5] n=45, THA	Morphine PCIA (n=14) *vs* FNB+PCIA (n=16) *vs* PCB+PCIA (n=15)	VAS pain scores—lower in the PCB group during first 4 h after surgery; rescue analgesia—lower in the PCB group compared with the PCIA group during the first 12 h after surgery; sensory block—similar between the PCB and the FNB groups with the exception of inconsistent spread to the upper anterior third of the thigh in the FNB group ($P<0.05$)
Bogoch and colleagues,[6] n=115, THA/TKA	PCB/PCIA (n=57) *vs* morphine PCIA (n=58)	VAS pain scores—NS; morphine consumption—reduced by 50% in the PCB group during the first 4 h after surgery ($P<0.001$)
Buckenmaier and colleagues,[7] n=10, THA (case series)	Continuous PCB with single-injection sciatic block and propofol sedation	Anaesthetic success—all 10 patients underwent THA without the need for conversion to GA
Chelly and colleagues,[8] n=26, open reduction and fixation of acetabular fractures (case–control study)	Continuous PCB with PCIA (n=13) *vs* PCIA (n=13)	Morphine consumption—lower in the PCB group in the PACU and on the first 2 days after operation
Chudinov and colleagues,[9] n=40, femur neck fracture	Preoperative continuous PCB (n=20) *vs* preoperative meperidine 1 mg kg^{-1} (n=20). Nineteen of the 20 patients received GA and 1/20 received spinal anaesthesia for surgery	Anaesthetic success rate—in the PCB group, the anaesthetic success rate was 3/20. Remaining patients received spinal anaesthesia (11/20), sciatic block (5/20), or GA (1/20) to enable completion of surgery; VAS pain scores—lower in the PCB group ($P<0.05$); sensory block: L1 blocked in 11/20. L2/L3 blocked in 20/20. L4 blocked in 15/20. L5 blocked in 13/20. S1 blocked in 7/20
Farny and colleagues,[11] n=45, lower extremity surgery	PCSNB	Mean maximum plasma level of lidocaine: 3.7 (2.2) μg ml^{-1}. T_{max} 61.7 (66.2) min
Gaillat and colleagues,[12] n=11, femur neck fracture	PCSNB with propofol sedation	Anaesthetic success—adequate surgical anaesthesia in 9/11 patients; adverse effects—one patient developed signs of local anaesthetic toxicity
Ganidagli and colleagues,[13] n=50, knee arthroscopic procedures	PCSNB *vs* femoral–sciatic nerve block	VAS pain scores—lower in the PCSNB group ($P<0.05$). Time to first analgesic request—NS. Rescue analgesia—lower in the PCB group ($P<0.05$); sensory block of femoral nerve—NS. Sensory block of obturator and lateral femoral cutaneous nerves was higher in the PCB group ($P<0.05$). Motor block of femoral and obturator nerves—NS
Hadzic and colleagues,[14] knee arthroscopy	PCSNB with propofol sedation and incisional lidocaine (n=25) *vs* GA with intra-articular bupivacaine (n=25)	VAS pain scores—the number of patients with a VAS of 0–2 out of 10 was higher in the PCSNB group (P=0.02)
Jankowski and colleagues,[20] n=60, knee arthroscopy	All patients received i.v. ketorolac, intra-articular bupivacaine, and one of the following: GA (n=20) *vs* spinal anaesthesia with propofol sedation (n=21) *vs* PCB with propofol sedation (n=19)	VAS pain scores—no difference between the spinal and the PCB groups. Pain scores in anaesthesia group were higher at all time points
Kaloul and colleagues,[21] n=60, TKA	PCIA morphine (n=20) *vs* PCIA+ FNB (n=20) *vs* PCIA+PCB (n=20)	VAS pain scores—no difference between PCB and FNB. Both techniques superior to PCIA (morphine); morphine consumption—both FNB and PCB reduced 48 h morphine consumption by 48% (P=0.0002) and 50% ($P<0.0002$), respectively, compared with PCIA morphine. The obturator nerve was more frequently blocked in the PCB group ($P<0.0001$). The difference was significant for motor block at 6 h (P=0.004) and 24 h for sensory block (P=0.02)
Kaloul and colleagues,[22] n=24, TKA	Continuous PCB (n=11) *vs* continuous FNB (n=11)	PCB was associated with higher early plasma levels ($P<0.0001$). AUC comparable. Maximum plasma levels were observed at 48 h and comparable for the two techniques
Luber and colleagues,[24] n=87, TKA	PCSNB with fentanyl/midazolam sedation	Anaesthetic success—71/87 patients were successfully operated on. The rest (16/87) required conversion to GA
Morin and colleagues,[27] n=90, TKA	(i) PCB (n=30); (ii) FNB (n=30); and (iii) femoral–sciatic nerve block (n=30). After surgery: diclofenac 50 mg t.i.d., PCIA piritramide 2 mg per 10 min	VAS pain scores—NS; piritramide consumption—48 h opioid consumption was lower in the femoral–sciatic group compared with the PCB and FNB groups (P=0.002)
Odoom and colleagues,[28] n=14	PCB with 40 ml bupivacaine 0.25% *vs* PCB with 40 ml bupivacaine 0.25%+epinephrine	Plasma bupivacaine concentrations were significantly higher in the plain bupivacaine group. The highest peak concentration was 4.54 μg ml^{-1} after plain bupivacaine and 1.62 μg ml^{-1} after bupivacaine with epinephrine. No patient developed signs of systemic toxicity
Ozalp and colleagues,[29] n=68, TKA	PCB with patient-controlled boluses (n=34) *vs* FNB with patient-controlled boluses (n=34)	VAS pain scores—NS; analgesic consumption—NS; sensory and motor block—NS

Continued

Table 2 *Continued*

Reference	Interventions	Outcomes
Parkinson and colleagues,[30] n=80	L3 approach PCB (n=20) *vs* L4–5 approach PCB (n=20) *vs* FNB with paresthesia (n=20) *vs* FNB with neurostimulator (n=20)	Sensory and motor block—no difference in incidence of block of the femoral and lateral femoral cutaneous nerves. Block of the obturator nerve was significantly higher in the PCB group
Raimer and colleagues,[32] n=63, TKA	Continuous PCB *vs* epidural *vs* PCIA (piritramide)	Opioid consumption and pain scores at rest and during movement were highest in the PCIA group. There was no difference between the PCB and the epidural groups
Siddiqui and colleagues,[33] n=34, THA	Continuous PCB+PCIA (n=17) *vs* PCIA (morphine) (n=17)	Morphine consumption—lower in the PCB group (P=0.02)
Simon and colleagues,[34] n=20, lower limb surgery	PCB and sciatic nerve block	Plasma concentrations of mepivacaine remained below 6 μg ml^{-1} in all but one patient who developed a peak plasma level of 7.07 μg ml^{-1} with no clinical signs of local anaesthetic toxicity
Souron and colleagues,[35] n=56, THA	PCB (n=27) *vs* intrathecal morphine (n=26)	VAS pain scores—lower in the intrathecal morphine group with the difference reaching significance at 30/90 min and 6/12/18 h; cumulative morphine consumption—lower in the intrathecal morphine group in the PACU and at 24 and 48 h after surgery (P<0.05)
Stevens and colleagues,[36] n=60, THA	PCB (n=30) *vs* sham procedure (skin puncture) (n=30)	VAS pain scores—lower in the plexus group up to 6 h after surgery; cumulative morphine consumption—significantly lower in the plexus group up to 12 h after surgery. Two of the 28 patients in the plexus group required rescue analgesia compared with 22/29 in the control group (P<0.0001)
Tokat and colleagues,[37] n=60, lower limb surgery	PCSNB *vs* femoral–sciatic nerve block	PCB group showed more consistent block of the lateral femoral cutaneous and obturator nerves (P<0.05). In addition, there was a higher rate of complete sensory block in the PCB group (P<0.05)
Turker and colleagues,[38] n=30, THA	Continuous PCB (n=15) *vs* epidural (n=15)	VAS pain scores—NS; rescue analgesia—NS; motor block (Bromage 0–3)—mean Bromage score was higher in the epidural group (P<0.001) at time 0 but not at subsequent time points
Vanterpool and colleagues,[40] n=20	PCB with sciatic nerve block (n=10) *vs* PCB without sciatic nerve block (n=10)	The combined blocks group showed higher peak concentrations of local anaesthetic which remained below the level for systemic toxicity
de Visme and colleagues,[10] n=29, proximal femur fracture	PCSNB with iliac crest block (n=15) *vs* spinal anaesthesia (n=14)	Anaesthetic success—no block failures in the spinal group. In the PCSNB group, anaesthesia was judged inadequate in 4/15 (27%) patients. Three of the four patients reported pain at incision that was relieved by a single bolus of 250 μg of alfentanil, whereas the fourth patient required sedation; VAS pain scores—NS
Vree and colleagues,[41] n=10, lower limb surgery	PCSNB	Maximum plasma concentrations of the R(+) and S(−) isomers were 1.54 (0.34) and 2.34 (0.51) μg ml^{-1}, respectively. There were no cases of toxicity
Watson and colleagues,[42] n=32, TKA	Continuous PCB with infusion of 0.1% levobupivacaine (n=16) *vs* continuous PCB with infusion of 0.9% saline (n=16)	VAS pain scores—NS; total morphine consumption was reduced by 41% in the levobupivacaine infusion group (19 *vs* 32 mg, P=0.04)

single-injection PCB is superior to single-injection FNB [Grade 3: Biboulet and colleagues[5] (A2)]. Single-injection PCB is, however, inferior to intrathecal morphine [Grade 3: Souron and colleagues[35] (B)].

PCB for anaesthesia for knee surgery

Four studies investigated PCB for anaesthesia for knee surgery. Luber and colleagues[24] described a series of 87 patients undergoing TKA using PCSNB with fentanyl/midazolam sedation. Sixteen of 87 patients (18%) experienced incomplete anaesthesia requiring conversion to GA. Aldahish and colleagues[1] found that PCSNB was as effective as epidural anaesthesia for major knee surgery. In the PCSNB group, there was one case of block failure.

Two RCTs used PCB for outpatient knee arthroscopy. In a comparison of PCB with GA and spinal anaesthesia,[20] there were no block failures in 19 patients receiving PCB. In a similar study comparing PCSNB with propofol sedation with GA,[14] 25 patients randomized to the PCSNB/propofol group successfully underwent arthroscopy without need for conversion to GA.

Conclusions

It is likely that PCB combined with either a sciatic nerve block or sedation or both is equivalent to GA and neuraxial anaesthesia for knee arthroscopy [Grade 2: Hadzic and colleagues[14] (A2), Jankowski and colleagues[20] (B), and Luber and colleagues[24] (C)].

There is, however, conflicting evidence to support the use of this technique as an alternative to GA and neuraxial anaesthesia for TKA [Grade 2: Aldahish and colleagues[1] (B) and Luber and colleagues[24] (C)].

PCB for analgesia after knee surgery

Two RCTs compared PCB with epidural analgesia.[1 32] Pain scores were found to be comparable between the epidural and the PCSNB groups. Four RCTs compared PCB with FNB. Two studies[21 29] found postoperative VAS pain

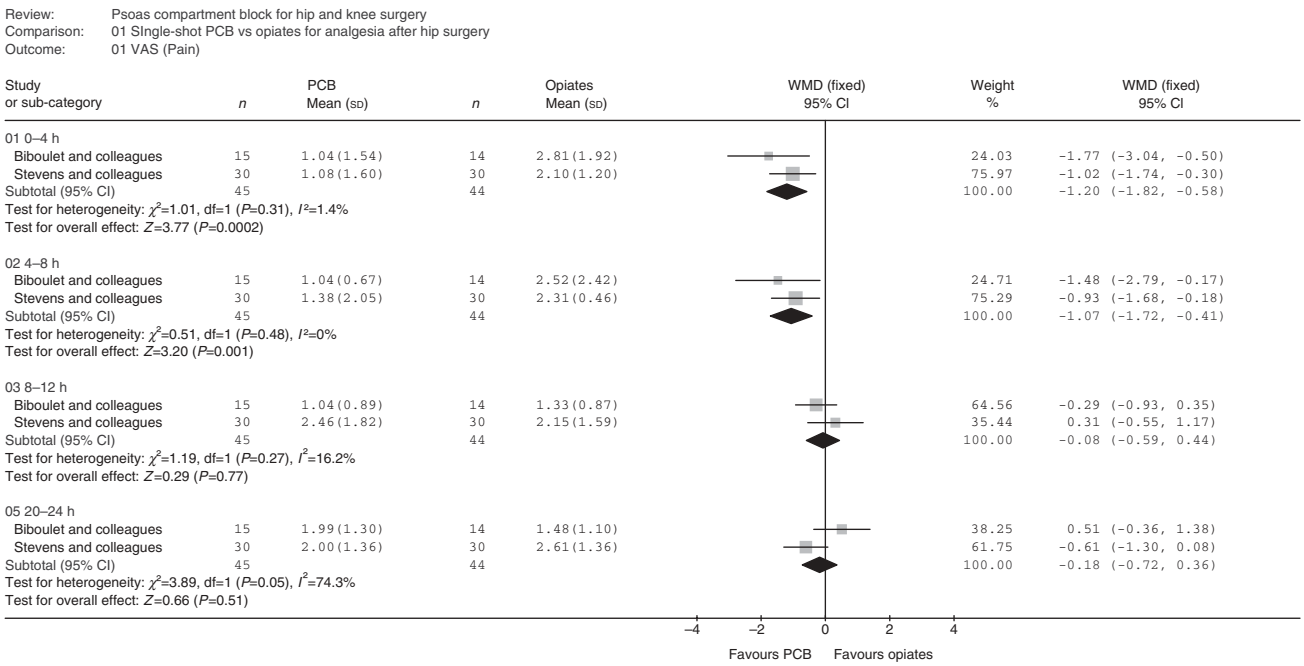

Fig 1 WMD between single-injection PCB and opiates for VAS pain scores measured at four time periods after surgery (0–4, 4–8, 8–12, and 20–24 h).

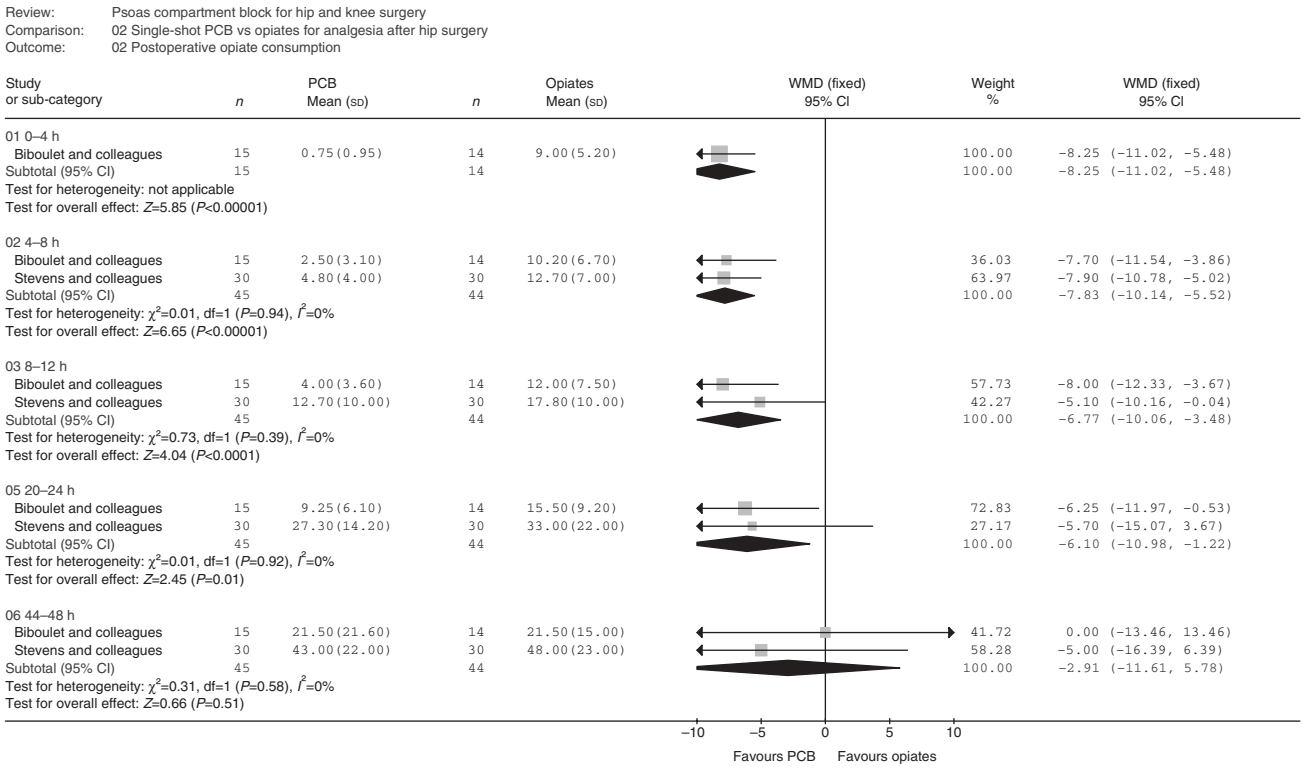

Fig 2 WMD between PCB and opiates for postoperative opiate consumption measured at five time periods after surgery (0–4, 4–8, 8–12, 20–24, and 44–48 h).

scores to be comparable. A comparison of continuous PCB with continuous FNB and continuous femoral–sciatic block[27] found no difference in supplemental piritramide consumption between the PCB and the FNB groups. However, patients receiving a femoral–sciatic nerve block required less rescue piritramide compared with the PCB group during the first 48 h after surgery (P=0.0048). Ganidagli and colleagues[13] compared PCSNB with

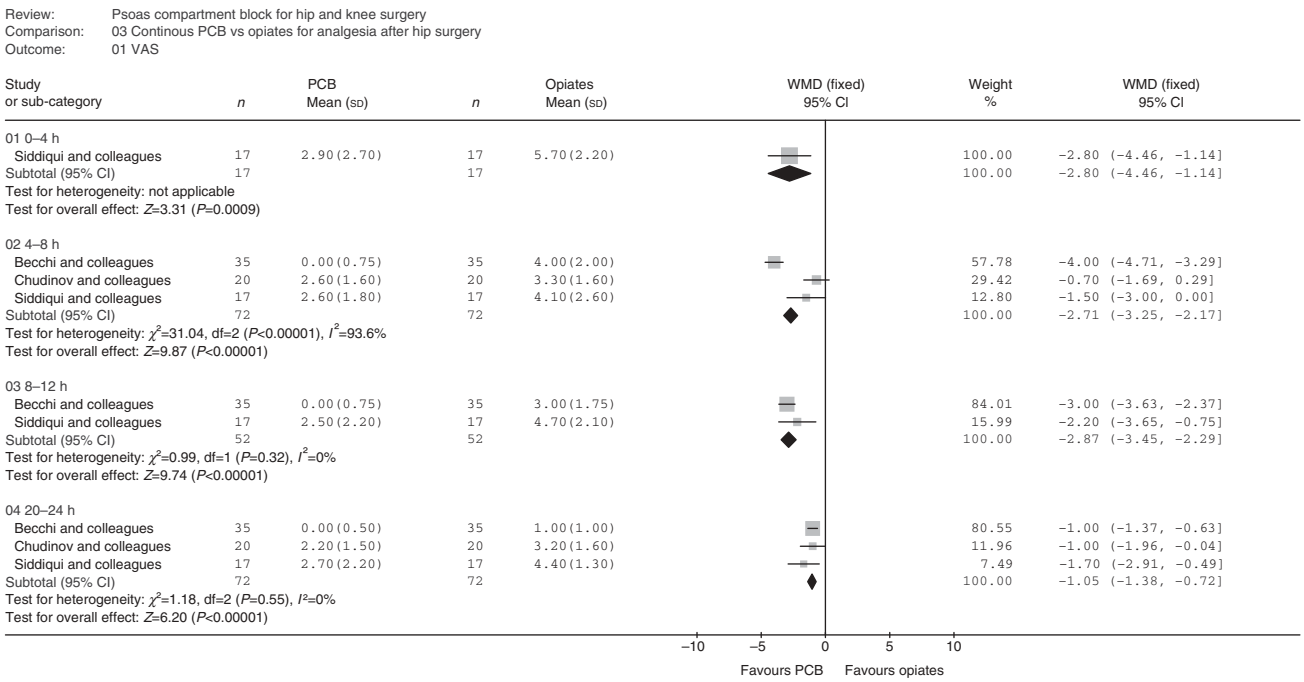

Fig 3 WMD between continuous PCB and opiates for VAS pain scores measured at four time periods after surgery (0–4, 4–8, 8–12, and 20–24 h).

femoral–sciatic nerve block and measured lower VAS scores in the PCSNB group at 10, 15, and 20 min after block injection ($P<0.05$). Meperidine consumption in the PCSNB group was lower during the first 24 h after surgery ($P<0.01$).

Three trials compared PCB with i.v. opiates for pain after knee surgery. Kaloul and colleagues[21] found continuous PCB to be superior to patient controlled i.v. anaesthesia (PCIA) for postoperative analgesia. This was statistically significant at 6 and 24 h after surgery ($P<0.0001$). The 48 h morphine consumption was reduced by 50% in the continuous PCB group. Other studies similarly found a 41% reduction in 48 h morphine consumption in their continuous PCB group[42] or lower pain scores in a PCSNB group both at rest ($P<0.001$) and during movement ($P=0.001$)[32] and postoperative opioid requirements were lower in the PCSNB group ($P<0.001$).

Conclusions

It is likely that continuous PCB is superior to patient-controlled opiate administration for pain after knee surgery [Grade 2: Kaloul and colleagues[21] (B), Raimer and colleagues[32] (B), and Watson and colleagues[42] (A2)].

Compared with other locoregional techniques: it is likely that continuous PCB combined with a sciatic nerve block is equivalent to epidural analgesia for pain relief after knee surgery [Grade 2: Aldahish and colleagues[1] (B) and Raimer and colleagues[32] (B)]. It is likely that there is no difference in analgesic effect between isolated PCB and FNB for knee surgery. However, when these blocks are combined with a sciatic nerve block, PCB provides superior analgesia compared with FNB [Grade 2: Kaloul and colleagues[21] (B), Morin and colleagues[27] (A2), Ganidagli and colleagues[13] (B), and Ozalp and colleagues[29] (B)].

Anterior vs *posterior approach to the lumbar plexus*

Four studies were identified in which the distribution of neural block after PCB and '3-in-1' block was compared.[13 21 30 37] The frequencies of block of the three branches of the lumbar plexus at 1 h after block injection were pooled using the random-effects model. If data at 1 h were not available, the data set closest to 1 h was used (Fig. 4). For block of the femoral and lateral femoral cutaneous nerves, this resulted in a RR ratio of 1.08 (0.96, 1.20) and 1.32 (0.54, 3.21), respectively. For obturator nerve block, this resulted in a RR ratio of 4.02 (1.47, 11.04).

Conclusion

It is likely that the posterior and anterior approaches to the lumbar plexus are equally effective in blocking the femoral and lateral femoral cutaneous nerves. The posterior approach is, however, more effective in blocking the obturator nerve [Grade 2: Ganidagli and colleagues[13] (B), Kaloul and colleagues[21] (B), Parkinson and colleagues[30] (B), and Tokat and colleagues[37] (B)].

Complications and plasma concentrations of local anaesthetics after PCB

Three studies measured plasma concentrations of local anaesthetic after injection into the psoas compartment.[11 34 41] In all three studies, plasma concentrations generally remained below toxic thresholds. No cases of local

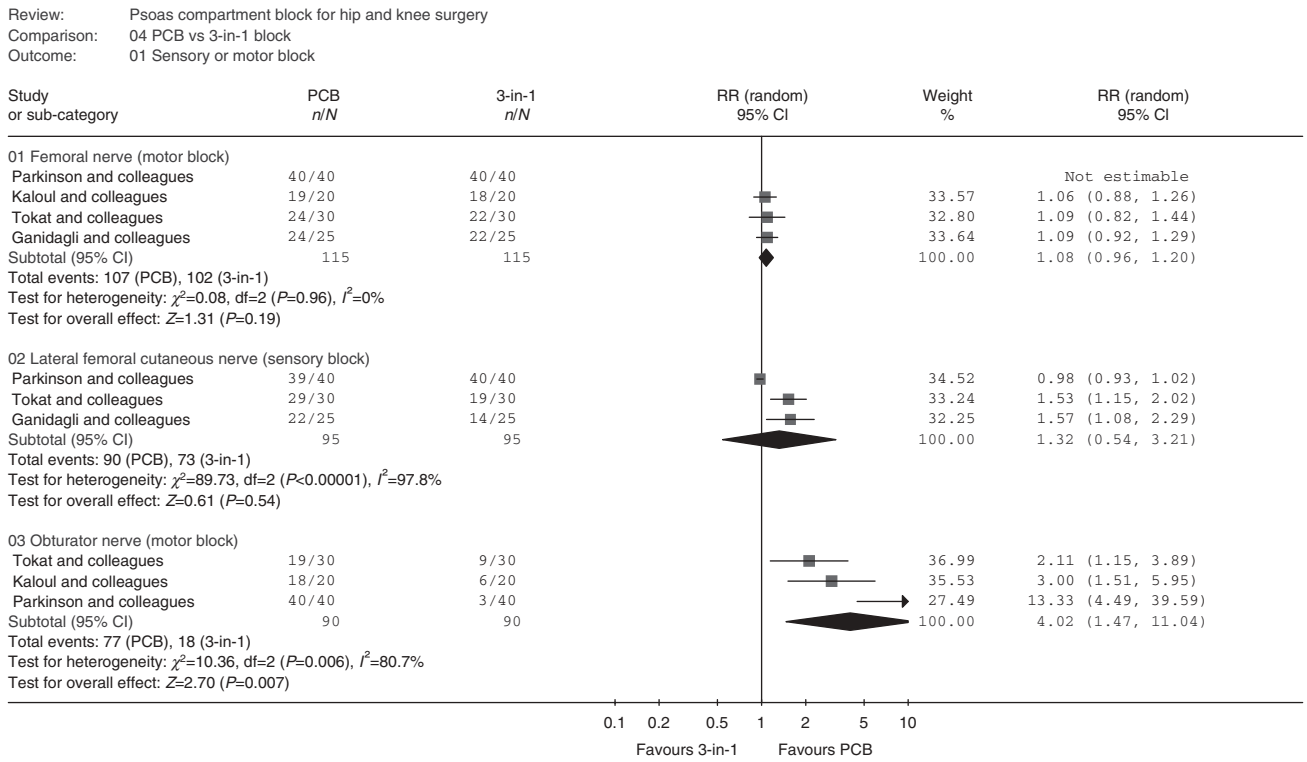

Fig 4 Rates of successful block of the three branches of the lumbar plexus by PCB *vs* the 3-in-1 block expressed as RR ratios.

anaesthetic toxicity were reported. Plasma concentrations of ropivacaine measured after PCB or PCSNB found that the combined block resulted in earlier peak concentrations which remained below the threshold for toxicity.[40] In a comparison of plasma concentrations of bupivacaine after PCB with bupivacaine 0.25% with and without epinephrine 1:200 000,[28] plasma bupivacaine concentrations were lower in the group receiving bupivacaine with epinephrine at 10, 15 ($P<0.05$), and 30 min ($P<0.025$). Peak plasma concentrations after bolus administration and continuous infusion of ropivacaine into the lumbar plexus via the anterior and posterior approaches[22] were significantly higher in the PCB group. However, after 48 h of continuous infusion, plasma levels were comparable between the two groups.

Of the 30 studies included for review, only one case of clinically evident systemic toxicity was described.[12] Epidural diffusion was the main complication described in the studies. This phenomenon was reported in 10 of the 30 studies included for review, with the incidence ranging from 3% to 27% (Table 3).

Table 3 Frequencies of epidural diffusion

Biboulet and colleagues[5]	4/15 (27%)
Bogoch and colleagues[6]	2/57 (3.5%)
Chudinov and colleagues[9]	1/20 (5%)
Farny and colleagues[11]	4/45 (9%)
Gaillat and colleagues[12]	1/11(9%)
Ganidagli and colleagues[13]	3/25 (12%)
Jankowski and colleagues[20]	1/19 (5%)
Ozalp and colleagues[29]	1/34 (3%)
Stevens and colleagues[36]	3/28 (10.7%)
Tokat and colleagues[37]	2/30 (7%)

Conclusions

There are indications that plasma concentrations of local anaesthetic after bolus administration into the psoas compartment remain below accepted levels of toxicity [Grade 3: Simon and colleagues[34] (C), Vree and colleagues[41] (C), and Farny and colleagues[11] (C)]. After bolus administration, peak plasma levels of local anaesthetic may be reduced by the addition of epinephrine to the injectate [Grade 3: Odoom and colleagues[28] (B)]. Compared with single-injection PCB, plasma concentrations of local anaesthetic increase more rapidly but remain below the threshold for toxicity when PCB is supplemented with a sciatic nerve block [Grade 3: Vanterpool and colleagues[40] (B)]. Compared with the anterior approach, peak plasma levels of local anaesthetic are significantly higher after the posterior approach. However, after continuous administration into the lumbar plexus, plasma levels are comparable for the posterior and anterior approaches [Grade 3: Kaloul and colleagues[22] (A2)].

Discussion

As hypothesized, the pooled data suggest that for postoperative analgesia, PCSNB is an alternative to neuraxial block and is superior to both i.v. opiates and the '3-in-1' block. There is, however, insufficient evidence to support

the use of PCB combined with a sciatic nerve block and sedation as an alternative to GA or neuraxial anaesthesia. These conclusions must, however, be interpreted against the background of several limitations of the review. No attempt was made to identify unpublished studies. This review may therefore be subject to publication bias. In addition, the majority of the comparative studies were of low quality. The main methodological shortcoming in the studies was failure to describe the method of randomization, blinding, or both that were used. The quality assessment was therefore carried out assuming a 'worst case scenario' in which the method of randomization, blinding, or both were considered inappropriate, if not specifically described. This had minor consequences for the evidence synthesis. A 'best case analysis' assuming the opposite would increase the number of high-quality studies. As a result, the level of evidence applied to Grade 2 conclusions would be increased to Grade 1, thus strengthening the various recommendations.

PCB for postoperative analgesia

The anterior approach to the lumbar plexus ('3-in-1' or inguinal paravascular block) was first described by Winnie in 1973. This technique is often recommended for lower limb surgery due to the potential complications of PCB.[2] This review, however, confirms earlier reports that Winnie's '3-in-1' block is at most a '2-in-1' block. In addition, PCB provides better analgesia. This may be related to the fact that the posterior approach results in consistent block of the obturator nerve. PCB may therefore be the true '3-in-1' block. For knee surgery, it has been demonstrated that addition of an obturator nerve block to femoral–sciatic nerve block significantly improves analgesia.[25 26] The posterior approach to the lumbar plexus may therefore be the peripheral block of choice for knee surgery. Similarly, for hip surgery, PCB was found to be superior to FNB for postoperative analgesia.[5] The authors of this study speculated that this may have been the result of more extensive anaesthesia by PCB in which the ilioinguinal, iliohypogastric, and genitofemoral nerves are also blocked. However, the data also indicate that single-injection PCB is of limited benefit as the duration of analgesia is limited to the first 4–8 h after block injection. Intrathecal morphine was found to provide superior and longer lasting analgesia after surgery.[35] For effective postoperative analgesia, a catheter technique may be used to extend the duration of analgesia.[4 8 9 32] However, continuous infusion into the lumbar plexus reduces morphine consumption, but does not completely eliminate it. This is probably the result of pain arising from structures innervated by the sacral plexus. This suggests that for optimal results, continuous PCB must be combined with either a sciatic nerve block or systemic analgesics.[16 17] Further research is required to determine if the sciatic nerve block should be continuous or single injection.

PCB for intraoperative anaesthesia

Several studies have reported more stable haemodynamics with PCB when compared with GA and neuraxial anesthesia.[10 36 38 43] Clinically, PCSNB with sedation has been successfully used for anaesthesia for cardiac compromised patients undergoing hip surgery.[2 15] In addition, PCB as a supplement to GA resulted in an anaesthetic-sparing effect and reduced blood loss.[36] Despite these encouraging observations, there is currently insufficient evidence to recommend the use of PCB as an alternative to GA or neuraxial anaesthesia for intraoperative anaesthesia. For hip surgery, the evidence for PCB in the intraoperative period is based on two small case series[7 12] and two low-quality studies.[9 10] In addition, PCB alone is insufficient for hip surgery. The addition of a sciatic nerve block and possibly sedation or supplementary analgesia appears to be required for successful anaesthesia.[9] For knee surgery, the evidence is more favourable. However, with the exception of one comparative study that involved TKA,[1] the studies identified primarily involved minor knee procedures such as knee arthroscopy. In addition, an 18% failure rate was noted in a case series involving 87 patients undergoing TKA using PCSNB with fentanyl and midazolam sedation.[20] More research is therefore required to define the role of PCB in intraoperative anaesthesia and to confirm the purported beneficial effects on variables such as intraoperative haemodynamics and perioperative blood loss.

Safety of PCB

In this review, a low incidence of complications was noted. The main complication described was epidural extension. The pharmacokinetic studies identified indicate that administration of local anaesthetic into the psoas compartment both as a bolus or as a continuous infusion is safe. However, reports of local anaesthetic toxicity cannot be ignored.[3] Awareness of toxic doses and use of the less cardio-toxic local anaesthetics is to be recommended. Other potential complications include total spinal anaesthesia, renal injury, and retroperitoneal haematoma. An ultrasound-guided posterior approach to the lumbar plexus has been described which may assist in needle placement and improve the safety profile of PCB.[23]

Conclusions

PCB for postoperative analgesia

Single-injection PCB is probably of limited benefit for postoperative analgesia as it only reduces pain during the first 4–8 h after surgery. A catheter technique may be applied to extend analgesia beyond 8 h. As PCB does not cover the sacral plexus, continuous PCB must be combined with either a sciatic nerve block or multimodal systemic analgesia.

PCB for intraoperative anaesthesia

It is likely that PCB combined with a sciatic nerve block and sedation is an effective alternative to GA and neuraxial anaesthesia for knee arthroscopy. PCB may be combined with GA for total arthroplasty. Further research is required to evaluate the efficacy of PCB combined with sciatic nerve block and sedation for hip and major knee surgery and to confirm potentially beneficial effects of PCB on intraoperative variables such as haemodynamic stability and perioperative blood loss.

Anterior vs *posterior approach to the lumbar plexus*

PCB is superior to Winnie's anterior approach to the lumbar plexus ('3-in-1' or inguinal paravascular block) for blocking all branches of the lumbar plexus. PCB is therefore the true '3-in-1 block'.

Complications of PCB

Epidural extension resulting in bilateral block was the main complication reported. The pharmacokinetic data indicate that PCB is a safe technique. Further studies on factors contributing to systemic toxicity and epidural extension and the role of ultrasound in improving the safety profile of PCB are required.

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